

N O T I C E

THIS DOCUMENT HAS BEEN REPRODUCED FROM
MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT
CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED
IN THE INTEREST OF MAKING AVAILABLE AS MUCH
INFORMATION AS POSSIBLE

"Made available under NASA sponsorship
in the interest of early and wide dis-
semination of Earth Resources Survey
Program information and without liability
for any use made thereof."

QUARTERLY PROGRESS REPORT I

8.1 - 100.46
CR-143756

ELECTROMAGNETIC DEEP-PROBING (100-1000 KMS)

OF THE EARTH'S INTERIOR FROM ARTIFICIAL SATELLITES:

CONSTRAINTS ON THE REGIONAL EMPLACEMENT OF CRUSTAL RESOURCES

NAS 5-26138

(E81-10046) ELECTROMAGNETIC DEEP-PROBING
(100-1000 KMS) OF THE EARTH'S INTERIOR FROM
ARTIFICIAL SATELLITES: CONSTRAINTS ON THE
REGIONAL EMPLACEMENT OF CRUSTAL RESOURCES
Quarterly Progress Report, 1 Jul. - 30 Sep. 63/43

N81-13406

Unclass
00046

John F. Hermance
Department of Geological Sciences
Brown University
Providence, RI 02912

Report Due Date: September 30, 1980
Date of Submission: October 20, 1980
Period Reported July 1, 1980-September 30, 1980

RECEIVED

OCT 20, 1980

SIS/902.6

TYPE II

M-009

Statement of Work

Objective

The objective of this investigation is to evaluate the applicability of electromagnetic deep-sounding experiments using natural sources in the magnetosphere by incorporating Magsat data with other geophysical data.

Approach

The investigator shall pursue the above objective through an analysis of Magsat satellite data, ground-based magnetic observations, appropriate reference field models, and other satellite data.

The objective will be pursued by seeking the optimal combination of observations which lead first to a global, and then to a regional, characterization of the conductivity of the Earth's upper mantle.

Tasks

The following tasks shall be performed by the investigator in fulfillment of the above objective:

a. Use data from Magsat satellite to constrain a long-period global "response function" for the average Earth at low latitudes over a period ranging from 6 hours to 27 days.

b. Synchronize the Magsat data with low-latitude ground-based observatory data to determine the vertical gradient of the respective magnetic field components. Use the vertical gradient of the appropriate components to independently ascertain the separation of external and internal field contributions.

c. Segregate the Magsat electromagnetic "response functions" according to the tectonic regime at the Earth's surface and evaluate systematic differences between regions having lateral scale sizes on the order of 1000 km or greater.

d. Theoretically evaluate problems of resolution and interpretation involving electromagnetic induction by temporally and spatially-varying magnetospheric sources in a rotating inhomogeneous Earth as observed at arbitrary points in space. Use these theoretical studies to constrain the interpretation of Magsat data as well as to propose further applications of satellite-based electromagnetic deep-sounding experiments.

e. Integrate the regional response functions with other geophysical data in order to constrain the joint interpretation of comprehensive physical models.

f. Prepare and submit to NASA periodic progress reports and a detailed final report documenting the results of this investigation.

FOCUS OF ACTIVITY

Personnel

This quarter we have mobilized personnel for this project and hired a Geophysical Data Analyst (Michael Rossen) to assist in computer program development and the analysis of data. Mr. Rossen, a Physics graduate, will be supported in part from the NASA/MAGSAT program.

Analysis of Ground Based Observatory Data (Task B)

Activity has focussed on developing a strategy for interfacing ground-based observatory data with the satellite data. We have analyzed the latitudinal dependence of magnetic storm disturbances for periods available from the World Data Center (1965 and 1967) in an effort to ascertain the suitability of assuming a P_1^0 harmonic dependence for the source field.

Problem: The dynamic source field seems to have a much more complicated spatial and temporal dependence than global induction workers have hitherto assumed.

Attempted Solution: We are attempting to synthesize a dynamical field model at high sampling rates (1 min. to 2.5 min.) which can be compared with the satellite data in the satellite frame of reference.

Theoretical Model Simulation (Task D)

We are in the process of evaluating the coupling of lateral heterogeneities within the earth (e.g. oceans) to source fields of finite dimensions. The vector components of the disturbance field are to be calculated at ground-level and at the satellite. The results of this calculation will provide a basis for deciding the optimal use of ground-based observations to a) minimize noise at the satellite altitude; b) the feasibility of evaluating a globally averaged response function for a laterally heterogeneous earth; c) methods for regionalizing the response function of the earth to analyze lithospheric tectonics.

Problem: The theoretical analysis in three-dimensions of global sized heterogeneities and arbitrary source-fields, easily over-runs the capability of most computer systems, particularly to model small scale features (the ocean-land interface) in the global framework.

Solution: We have reduced the problem to a two-dimensional model which seems to be valid at the depth of penetration and radius of curvature relations which pertain. This has to be evaluated! We are beginning this analysis with the E-polarization mode and will be looking at some very simple source field and geometrical relationships to gain insight into the problem.

Interaction with Other Workers

The Principal Investigator conferred with Joe Cain when visiting Denver on other business and was appraised of certain problems of low-amplitude noise on the MAGSAT data. Because of the relatively low level of magnetic disturbance during the MAGSAT mission we are postponing the actual analysis of any MAGSAT data until the noise problem is minimized.

Filtering programs, developed by our group, for the analysis of space/time series have been forwarded to Dr. Cain and are available for use by other MAGSAT investigators. Program listings are attached.

```

SUBROUTINE FILT(X,N,DEL,FRC,PASS,HIPASS,XX,W)
X IS THE ORIGINAL DATA
THE SUBROUTINE CONVERTS X(I) TO FILTERED DATA IN THE OBJECT PROGRAM
N IS THE TOTAL NUMBER OF DATA POINTS
DEL IS THE SAMPLING INTERVAL IN UNIT TIME
FRC IS THE HALF POWER (AMP) POINT IN CYCLES PER UNIT TIME
FILTER IS GENERATED BY CONVOLVING ORIGINAL DATA WITH A GAUSSIAN
LOW PASS OUTPUT IS THE SMOOTHED DATA
HIGH PASS OUTPUT IS THE ORIGINAL DATA MINUS THE SMOOTHED DATA
PASS IS THE SIGNAL AFTER A LOW-PASS FILTER
HIPASS IS THE SIGNAL AFTER A HIGH PASS FILTER
TAILS ON THE ORIGINAL DATA ARE CREATED BY REITERATING FIRST AND LAST
PCINTS. THESE TAILS ARE SUPPRESSED IN THE FILTER OUTPUT.
DIMENSION X(1),HIPASS(1),PASS(1),XX(1),W(1)
SIGMA=SQRT(.69315/(2.0*(3.1416**2.0)*(FRC**2.0)))
TF=SQRT(5.0*2.0*(SIGMA**2.0))
M=TF/DEL
AM=M
TE=AM*DEL
NM=N+M
N1=N+1
NM1=N+M+1
NMM=N+M+M
M1=M+1
MM1=M+M+1
SUM=0.0
DO 3 I=1,M
XX(I)=X(1)
3 CONTINUE
DO 4 I=NM1,NMM
XX(I)=X(N)
4 CONTINUE
DO 5 I=1,N
K=I+M
XX(K)=X(I)
5 CONTINUE
DO 6 K=1,MM1
C=K-1
TC=C*DEL
W(K)=1.0/EXP(((TF-TC)**2)/(2.0*(SIGMA**2)))
6 CONTINUE
SUM=0.0
DO 61 K=1,MM1
SUM=W(K)+SUM
61 CONTINUE
SUMA=0.0
DO 63 K=1,MM1
W(K)=W(K)/SUM
SUMA=W(K)+SUMA
63 CONTINUE
DO 6 I=1,N
SUMA=0.0
DO 7 K=1,MM1
J=I+K-1
SUMA=SUMA+XX(J)*W(K)

```

```

FIL00010
FIL00020
FIL00030
FIL00040
FIL00050
FIL00060
FIL00070
FIL00080
FIL00090
FIL00100
FIL00110
FIL00120
FIL00130
FIL00140
FIL00150
FIL00160
FIL00170
FIL00180
FIL00190
FIL00200
FIL00210
FIL00220
FIL00230
FIL00240
FIL00250
FIL00260
FIL00270
FIL00280
FIL00290
FIL00300
FIL00310
FIL00320
FIL00330
FIL00340
FIL00350
FIL00360
FIL00370
FIL00380
FIL00390
FIL00400
FIL00410
FIL00420
FIL00430
FIL00440
FIL00450
FIL00460
FIL00470
FIL00480
FIL00490
FIL00500
FIL00510
FIL00520
FIL00530
FIL00540
FIL00550

```

FILE: FIIT PORTPAN A

*** Crown University Computer Center ***

7 CONTINUE
 PASS(I) = SUMA
 HIPASS(I) = X(I) - SUMA
8 CONTINUE
10 CONTINUE
12 CONTINUE
11 RETURN
 END

FIL00560
FIL00570
FIL00580
FIL00590
FIL00600
FIL00610
FIL00620
FIL00630

SUBROUTINE PASS4(X,XNEW,WEIGHT,NEFF,N,NMOD,DT,DTMOD,
* PERIOD,SEL,LXTND,LSPRS)

PAS00010

PAS00020

PAS00030

PAS00040

PAS00050

PAS00060

PAS00070

PAS00080

PAS00090

PAS00100

PAS00110

PAS00120

PAS00130

PAS00140

PAS00150

PAS00160

PAS00170

PAS00180

PAS00190

PAS00200

PAS00210

PAS00220

PAS00230

PAS00240

PAS00250

PAS00260

PAS00270

PAS00280

PAS00290

PAS00300

PAS00310

PAS00320

PAS00330

PAS00340

PAS00350

PAS00360

PAS00370

PAS00380

PAS00390

PAS00400

PAS00410

PAS00420

PAS00430

PAS00440

PAS00450

PAS00460

PAS00470

PAS00480

PAS00490

PAS00500

PAS00510

PAS00520

PAS00530

PAS00540

PAS00550

ROUTINE BAND-PASS FILTERS BY CONVOLVING THE INPUT SERIES WITH
A DAMPED SINE WAVE. FREQUENCY RESPONSE IS GAUSSIAN SHAPED,
CENTERED AT THE GIVEN FREQUENCY, WITH A NORMALIZED SELECTIVITY,
GIVEN BY SEL.

SUBPROGRAMS REQUIRED:

NCNE

DIMENSION X(1),XNEW(1),WEIGHT(1)

SUBROUTINE PARAMETERS:

X -ARRAY CONTAINING BOTH INPUT AND OUTPUT SERIES OF FILTER

XNEW -TEMPORARY STORAGE ARRAY (CONTAINS EXTENDED INPUT
SERIES, SHOULD BE LARGE ENOUGH TO ALLOW FOR THIS)

WEIGHT-TEMPORARY STORAGE ARRAY (CONTAINS FILTER FUNCTION,
DIMENSION SHOULD BE GREATER THAN $(3*PERIOD)/SEL*DT)+1$

NEFF -THE EFFICIENCY PARAMETER: THE FILTER OUTPUTS POINTS
AT INTERVALS NEFF*DT (NEFF IS USUALLY 1)

N -NUMBER OF POINTS IN INPUT SERIES

NMOD -NUMBER OF POINTS IN OUTPUT SERIES ($NMOD=(N-1)/NEFF+1$)

DT -THE SAMPLING INTERVAL BETWEEN POINTS IN INPUT SERIES

DTMOD -THE SAMPLING INTERVAL BETWEEN POINTS IN OUTPUT SERIES

PERIOD-CENTER PERIOD (CONVERTED IMMEDIATELY TO $FRQ=1/PERIOD$)

SEL -SELECTIVITY OF THE FILTER: IF $FRQ(F)$ IS THE FREQUENCY
AT WHICH THE FILTER RESPONSE IS DOWN TO $1/E$ OF ITS

MAXIMUM VALUE, THEN $SEL=(FRQ(F)-FRQ(L))/FRQ$

LXTND -PARAMETER CONTROLLING TREATMENT OF THE ENDS OF X:

=1 ZERO MEAN IS ASSUMED FOR X, ZEROS ARE ADDED TO
EACH END OUT TO $1/2$ THE FILTER LENGTH

=2 X IS AVERAGED OVER ONE PERIOD INTO THE SERIES
AND THE MEAN USED TO EXTEND THE INPUT SERIES

LSPRS -PARAMETER CONTROLLING TREATMENT OF OUTPUT SERIES:

=0 EACH POINT WITHIN 1 PERIOD OF EACH END OF THE
SERIES IS MULTIPLIED BY ZERO TO MINIMIZE

TRANSIENTS INTRODUCED BY THE FILTER

=1 NO MODIFICATION IS PERFORMED

PI=3.141596

FRQ=1.0/PERIOD

TC IS THE FORWARD LENGTH OF THE FILTER IN TIME
CONSTANTS OF THE DAMPING TERM

TC=2.0

S IS THE UNNORMALIZED SELECTIVITY

S=SEL*FRQ*2.0*PI

C---->		PAS00560
C---->	TFILT IS THE FORWARD LENGTH OF THE FILTER IN REAL TIME	PAS00570
C---->		PAS00580
	TFILT=TC*4.0/S	PAS00590
C---->		PAS00600
C---->	OMEGA IS THE CENTER FREQUENCY IN RADIAN PER UNIT TIME	PAS00610
C---->		PAS00620
	OMEGA=2.0*PI*FRQ	PAS00630
C---->		PAS00640
C---->	MFILT IS THE NUMBER OF SAMPLING BITS IN 1/2 OF THE FILTER	PAS00650
C---->	TFILT IS ADJUSTED LENGTH OF THE SERIES	PAS00660
C---->	NFILT IS TOTAL NUMBER OF SAMPLING BITS IN THE FILTER	PAS00670
C---->		PAS00680
	MFILT=TFILT/DT	PAS00690
	TFILT=MFILT	PAS00700
	TFILT=TFILT*DT	PAS00710
	NFILT=2*MFILT+1	PAS00720
	AEFF=NEFF	PAS00730
C---->		PAS00740
C---->	THE FILTER FUNCTION IS GENERATED	PAS00750
C---->		PAS00760
	DC 10 I=1,NFILT	PAS00770
	T=I-1	PAS00780
	T=T*DT-TFILT	PAS00790
	WEIGHT(I)=2.0*S*(SQRT(PI))*CCS(OMEGA*T)/EXP(S*S*T*T/4.0)	PAS00800
	10 CONTINUE	PAS00810
C---->		PAS00820
C---->	THE ENDS ARE EXTENDED	PAS00830
C---->		PAS00840
	IF(LXTND.EQ.2) GO TO 11	PAS00850
	XEND=0.0	PAS00860
	XBEGIN=0.0	PAS00870
	IF(LXTND.EQ.1) GO TO 21	PAS00880
11	KEX=1.0/FRQ/DT	PAS00890
	KEX=KEX+1	PAS00900
	SUM=0.0	PAS00910
	AFX=KEX	PAS00920
	DC 100 I=1,KEX	PAS00930
	SUM=X(I)+SUM	PAS00940
100	CONTINUE	PAS00950
	XBEGIN=SUM/AFX	PAS00960
	KKEX=N-KEX+1	PAS00970
	SUM=0.0	PAS00980
	DC 110 I=KKEX,N	PAS00990
	SUM=X(I)+SUM	PAS01000
110	CONTINUE	PAS01010
	XEND=SUM/AFX	PAS01020
C---->		PAS01030
C---->	NEW IS THE NUMBER OF POINTS IN THE NEW SERIES	PAS01040
C---->		PAS01050
21	NEW=N+2*MFILT	PAS01060
	NEND=MFILT+N	PAS01070
	DC 20 I=1,MFILT	PAS01080
	IBEGIN=I	PAS01090
	IEND=I+NEND	PAS01100

ORIGINAL PAGE 1
OF FOUR QUALITY

XNEW(1BEGIN)=XBEGIN	PAS01110
XNEW(1END)=XEND	PAS01120
20 CONTINUE	PAS01130
C----->	PAS01140
C-----> THE ORIGINAL SERIES IS ADDED TO THE MIDDLE OF THE NEW SERIES	PAS01150
C-----> XNEW IS THE EXTENDED SERIES	PAS01160
C----->	PAS01170
DC 30 I=1,N	PAS01180
J=I+MFILT	PAS01190
XNEW(J)=X(I)	PAS01200
30 CCNTINUE	PAS01210
C----->	PAS01220
C-----> THE EXTENDED SERIES IS CONVOLVED WITH THE	PAS01230
C-----> FILTER IMPULSE RESPONSE FUNCTION	PAS01240
C----->	PAS01250
NMOD=0	PAS01260
IMCD=0	PAS01270
DO 40 I=1,N,NEFF	PAS01280
SUM=0.0	PAS01290
DC 50 JFILT=1,NFILT	PAS01300
K=I+JFILT-1	PAS01310
SUM=SUM+XNEW(K)*WEIGHT(JFILT)	PAS01320
50 CONTINUE	PAS01330
IMCD=IMOD+1	PAS01340
NMCD=IMCD	PAS01350
X(IMOD)=DT*SUM/(2.0*PI)	PAS01360
40 CONTINUE	PAS01370
IF(LSPRS.EQ.1) GO TO 31	PAS01380
C----->	PAS01390
C-----> LTRANS IS THE LENGTH OF THE TRANSIENT	PAS01400
C----->	PAS01410
LTRANS=PERIOD/(DT*AEFF)	PAS01420
LBEGIN=LTRANS+1	PAS01430
LEND=NMOD-LTRANS	PAS01440
LEND1=LEND+1	PAS01450
DO 60 I=1,LTRANS	PAS01460
X(I)=0.00001	PAS01470
60 CCNTINUE	PAS01480
DC 80 I=1,LEND1,NMOD	PAS01490
X(I)=0.00001	PAS01500
80 CONTINUE	PAS01510
11 DTMOD=DT*NEFF	PAS01520
RETURN	PAS01530
END	PAS01540

SUBROUTINE PHILTR (X,Y,LX,LY,DELT,PERIOD,SEL,KEND)

```

C .....PHI00020
C .....PHI00030
C X IS THE ARRAY CONTAINING THE TIME SERIES TO BE FILTERED. PHI00040
C ALSO THE FILTERED SERIES IS RETURNED IN X. PHI00050
C Y IS A TEMPORARY STORAGE ARRAY. THE DIMENSION OF Y (IN PHI00052
C THE MAIN PROGRAM) MUST ALLOW FOR EXTENDING THE X ARRAY PHI00054
C BY A PERIOD LENGTH ON EACH END TO ALLOW FOR FILTER PHI00056
C SHOCK (KEND=2) PHI00058
C .....PHI00059
C .....PHI00060
C .....PHI00064
C .....PHI00066
C LX IS THE NUMBER OF POINTS CONTAINED IN X. PHI00068
C LY IS THE NUMBER OF POINTS CONTAINED IN Y
C DELT IS THE SAMPLING INTERVAL. PHI00070
C PERIOD IS THE CENTER PERIOD OF THE BAND-PASS FILTER. PHI00080
C SEL IS THE SELECTIVITY OF THE FILTER. IT IS DEFINED PHI00090
C AS  $(F2-F1)/F0$  WHERE  $F0$  IS THE CENTER OF THE BAND; PHI00100
C  $F1$  AND  $F2$  ARE THE FREQUENCIES TO EACH SIDE OF  $F0$  PHI00110
C WHERE THE AMPLITUDE RESPONSE OF THE FILTER IS EQUAL PHI00120
C TO  $1/2$ . THE RESPONSE AT  $F0$  IS 1. PHI00130
C KEND: =0, THE X ARRAY IS FILTERED ASSUMING THAT THE VALUES PHI00140
C ARE ZERO OUTSIDE THE ARRAY. THE ENDS ARE NOT PHI00150
C EXTENDED. PHI00160
C =1, A CCSINE TAPER IS APPLIED TO THE ENDS OF THE INPUT PHI00170
C SERIES. THE ENDS ARE NOT EXTENDED. PHI00180
C =2, THE ENDS OF THE INPUT SERIES ARE EXTENDED BY ONE PHI00190
C CENTER PERIOD AND A COSINE TAPER IS APPLIED TO THE PHI00200
C EXTENSION. PHI00210
C .....PHI00220
C COMMENT: THE FILTER DOES NOT HAVE ZERO PHASE SHIFT, SO THE DATA PHI00230
C IS FILTERED FORWARD IN TIME AND THEN THE FILTER IS PHI00240
C APPLIED IN THE REVERSE DIRECTION TO OFFSET THE PHASE SHIFT. PHI00250
C .....PHI00260
C SUBPROGRAMS REQUIRED: PHI00270
C NONE PHI00280
C .....PHI00290
C .....PHI00300
C DIMENSION X(LX),Y(LY) PHI00310
C COMPLEX ZO,ZOC,Z1,CNE,C PHI00320
C INTEGER EXTEND,TAPER PHI00390
C FG=1.0/PERIOD PHI00400
C SELECT = SEL*SQRT(2.)*DELT*FG*1.8394 PHI00410
C C=(0.0,1.0) PHI00420
C ONE=(1.0,0.0) PHI00430
C PI=3.1415926 PHI00440
C EXTEND=0 PHI00450
C ZO=(1.0+SELECT)*CEXP(-2.0*PI*C*FO*DELT) PHI00460
C ZCC=CCNJG(ZO) PHI00470
C Z1=CEXP(-2.0*PI*C*FO*DELT) PHI00480
C HO=(CABS(Z1-ZO)*CABS(Z1-ZOC))/(CABS(Z1-ONE)*CABS(Z1+ONE)) PHI00490
C AG=HO/REAL(ZC*ZOC) PHI00500
C A2=AO

```

```

P1=(REAL(ZO+ZOC))/(REAL(ZC+ZCC))
P2=1.0/(REAL(ZO+ZOC))
TAPFR = 1
LXNEW=LX
IF(KEND.EQ.0) GO TO 35
IF(KEND.EQ.1) GO TO 25
EXTEND=PERIOD/DELT+1
----->
----->      EXTEND THE ENDS OF THE INPUT TIME SERIES
----->
      DC 10 IL=1,LX
      X(LX+EXTEND-IL+1)=X(LX-IL+1)
10    CCNTINUE
      DC 20 IE=1,EXTEND
      X(IE)=X(EXTEND+1)
      X(LX+EXTEND+IE)=X(LX+EXTEND)
20    CONTINUE
      LXNEW=LX+2*EXTEND
25    CONTINUE
----->
----->      APPLY A COSINE TAPER TO EITHER THE INPUT OR EXTENDED
----->      TIME SERIES
----->
      TAPER= PERIOD/(3.0*DELT)+1
      DO 30 IT=1,TAPER
      THETA=(PI/2.0)*(TAPER-IT+1)/TAPER
      X(IT)=X(TAPER+1)*COS(THETA)
      X(LXNEW-IT+1)=X(LXNEW-TAPER)*COS(THETA)
30    CCNTINUE
25    CONTINUE
----->
----->      FILTER IN THE DIRECTION OF INCREASING TIME
----->
      Y(1)=-A0*X(1)
      Y(2)=-A0*X(2)+B1*Y(1)
      DC 40 IL=3,LXNEW
      Y(IL)=-A0*X(IL)+A2*X(IL-2)+B1*Y(IL-1)-B2*Y(IL-2)
40    CCNTINUE
      DC 50 IT=1,TAPER
      THETA=(PI/2.0)*(TAPER-IT+1)/TAPER
      Y(IT)=Y(TAPER+1)*COS(THETA)
      Y(LXNEW-IT+1)=Y(LXNEW-TAPER)*COS(THETA)
50    CCNTINUE
----->
----->      FILTER IN THE DIRECTION OF DECREASING TIME
----->
      X(LXNEW)=-A0*Y(LXNEW)
      X(LXNEW-1)=-A0*Y(LXNEW-1)+B1*X(LXNEW)
      DC 60 IL=3,LXNEW
      X(LXNEW-IL+1)=-A0*Y(LXNEW-IL+1)+A2*Y(LXNEW-IL+3)
      *      +B1*X(LXNEW-IL+2)-B2*X(LXNEW-IL+3)
60    CCNTINUE
      DC 70 IL=1,LX
      X(IL)=X(EXTEND+IL)
70    CCNTINUE

```

PHI00510
 PHI00520
 PHI00530
 PHI00540
 PHI00550
 PHI00560
 PHI00570
 PHI00580
 PHI00590
 PHI00600
 PHI00610
 PHI00620
 PHI00630
 PHI00640
 PHI00650
 PHI00660
 PHI00670
 PHI00680
 PHI00690
 PHI00700
 PHI00710
 PHI00720
 PHI00730
 PHI00740
 PHI00750
 PHI00760
 PHI00770
 PHI00780
 PHI00790
 PHI00800
 PHI00810
 PHI00820
 PHI00830
 PHI00840
 PHI00850
 PHI00860
 PHI00870
 PHI00880
 PHI00890
 PHI00900
 PHI00910
 PHI00920
 PHI00930
 PHI00940
 PHI00950
 PHI00960
 PHI00970
 PHI00980
 PHI00990
 PHI01000
 PHI01010
 PHI01020
 PHI01030
 PHI01040

FILE: PHILTR FORTRAN A

*** Brown University Computer Center ***

BE1URN
END

PHI01050
PHI01060

```

C.....SMQ00010
  SUPROUTINE SMOOTH(X,N,M).....SMQ00020
C.....SMQ00030
C.....SMQ00040
C  PROGRAM TO SMOOTH DATA USING EQUALLY WEIGHTED RUNNING AVERAGE SMQ00050
C.....SMQ00060
C      X IS THE INPUT DATA SERIES. SMQ00070
C      N IS THE NUMBER OF INPUT DATA POINTS. SMQ00080
C      M IS THE NUMBER OF POINTS IN THE AVERAGING INTERVAL. SMQ00090
C.....SMQ00100
C.....SMC00110
  DIMENSION X(1),SMUTH(3000) SMQ00120
  A=M SMQ00130
  IBEGIN=(M+1)/2 SMQ00140
  IEND=N-IBEGIN+1 SMQ00150
  LM=(M-1)/2 SMQ00160
  DO 10 I=IBEGIN,IEND SMQ00170
    SUM=0.0 SMQ00180
    DO 20 LSMUTH=1,M SMQ00190
      J=LSMUTH-1 SMQ00200
      J=I+J-LM SMQ00210
      SUM=SUM+X(J) SMQ00220
20 CONTINUE SMQ00230
    SMUTH(I)=SUM/A SMQ00240
10 CONTINUE SMC00250
C.....SMQ00260
C      THIS STEP OVEREMPHASIZES SMOOTHING AT ENDPOINTS. SMC00270
C.....SMQ00280
  DO 30 I=1,N SMQ00290
    IF(I.LT.IBEGIN) SMUTH(I)=SMUTH(IBEGIN) SMQ00300
    IF(I.GT.IEND) SMUTH(I)=SMUTH(IEND) SMQ00310
30 CONTINUE SMQ00320
C.....SMQ00330
C      THIS STEP DESTROYS THE ORIGINAL DATA SERIES,REPLACING IT SMQ00340
C      WITH THE SMOOTHED SERIES. SMQ00350
C.....SMQ00360
  DO 40 I=1,N SMQ00370
    X(I)=SMUTH(I) SMQ00380
40 CONTINUE SMQ00390
  RETURN SMQ00400
  END
  SUBROUTINE SPLIT(N,ISIT)

```